ФЕДЕРАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ ЦЕНТР
«ФУНДАМЕНТАЛЬНЫЕ ОСНОВЫ БИОТЕХНОЛОГИИ»
РОССИЙСКОЙ АКАДЕМИИ НАУК

ГЕОГРАФИЧЕСКИЙ ФАКУЛЬТЕТ
МГУ имени М.В. Ломоносова

Seasonal and spatial variation of methane content in small reservoirs during the summer period

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Tasks and objects of study

CH_4

- Climate forcing
- Ecological conditions
- Individual regime of water objects – mathematical models - verification

Study of a question in Russia

Methane study in Russia (A.N.Dzuban, U.A. Fedorov et al…):

- natural lakes of different genesis, morphometry, mixing types, trophycal status in:
Baltic States, Karelia, Moscow region, Volga upper stream, North Dvina basin, mouth Amur floodplain,
- Reservoir cascade Volga-Kama (!!!pollution),
- Tsimlyansk reservoir on Don river).

! No measurements and estimations of concentration and emission of methane in reservoirs of Russia with slow water exchange with long stratification period and anoxic conditions (without pollution)

Study of a question in Russia

Expedition measurements:

- usually in summer in periods of different stratification conditions and primary production intensity

- some lakes and reservoirs were studied several years during summer period, some were studied in season time scale

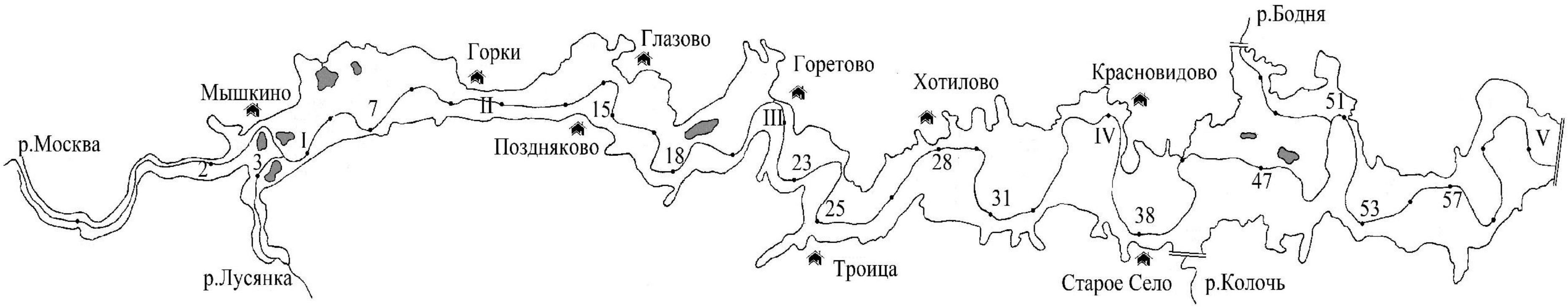
- only Plezheevo lake and Rybinsk reservoir were studied during a whole year cycle

Many results were received during short expeditions.
We have few seasonal measurements on Russian water objects which can be used for verification of mathematical models

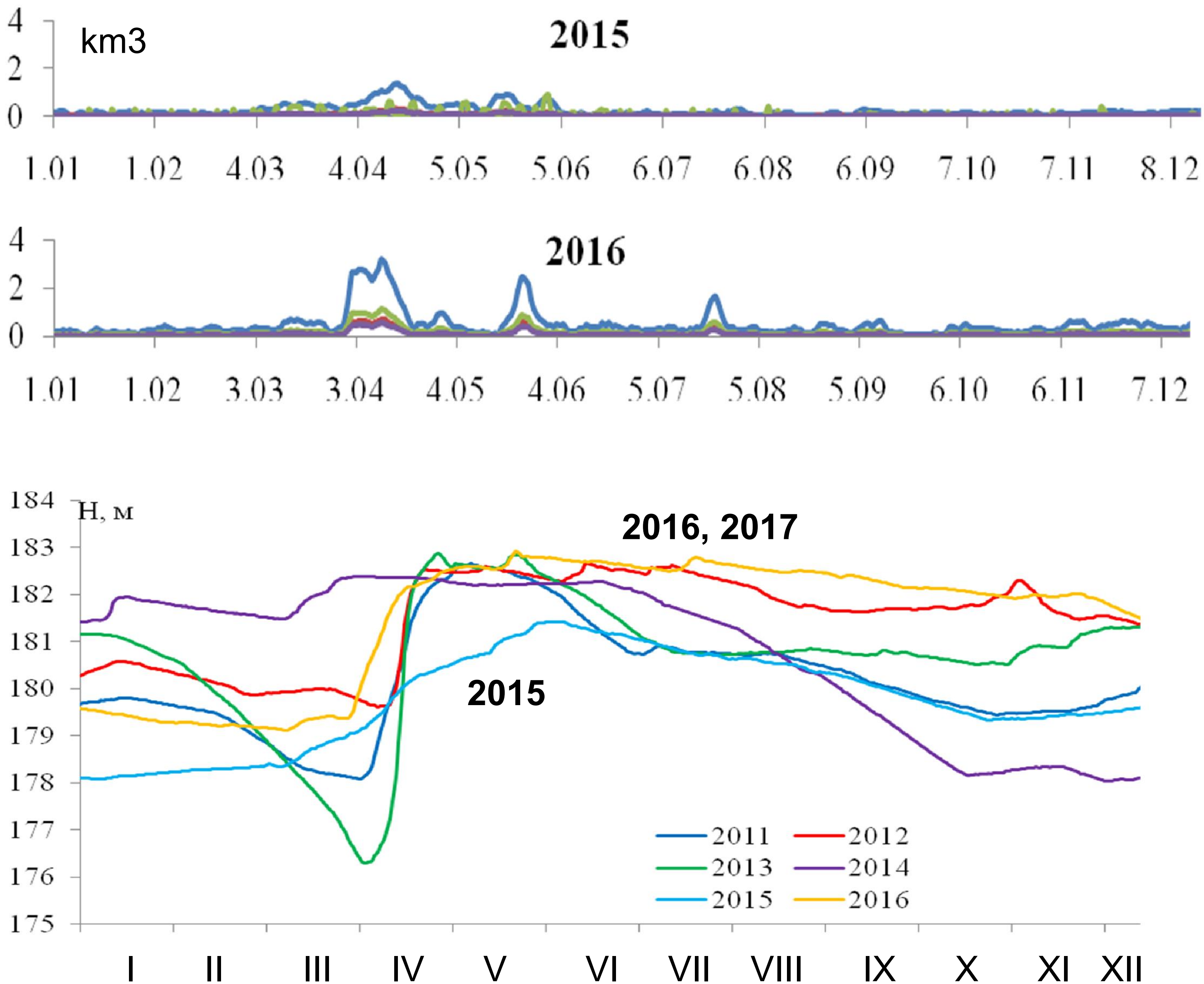
Characteristic of an object

Mojaisk reservoir

Water exchange: $W_{inflow}/W_{reservoir} < 2$ year^{-1}
Relatively deep ($H_{max} = 23$ m)

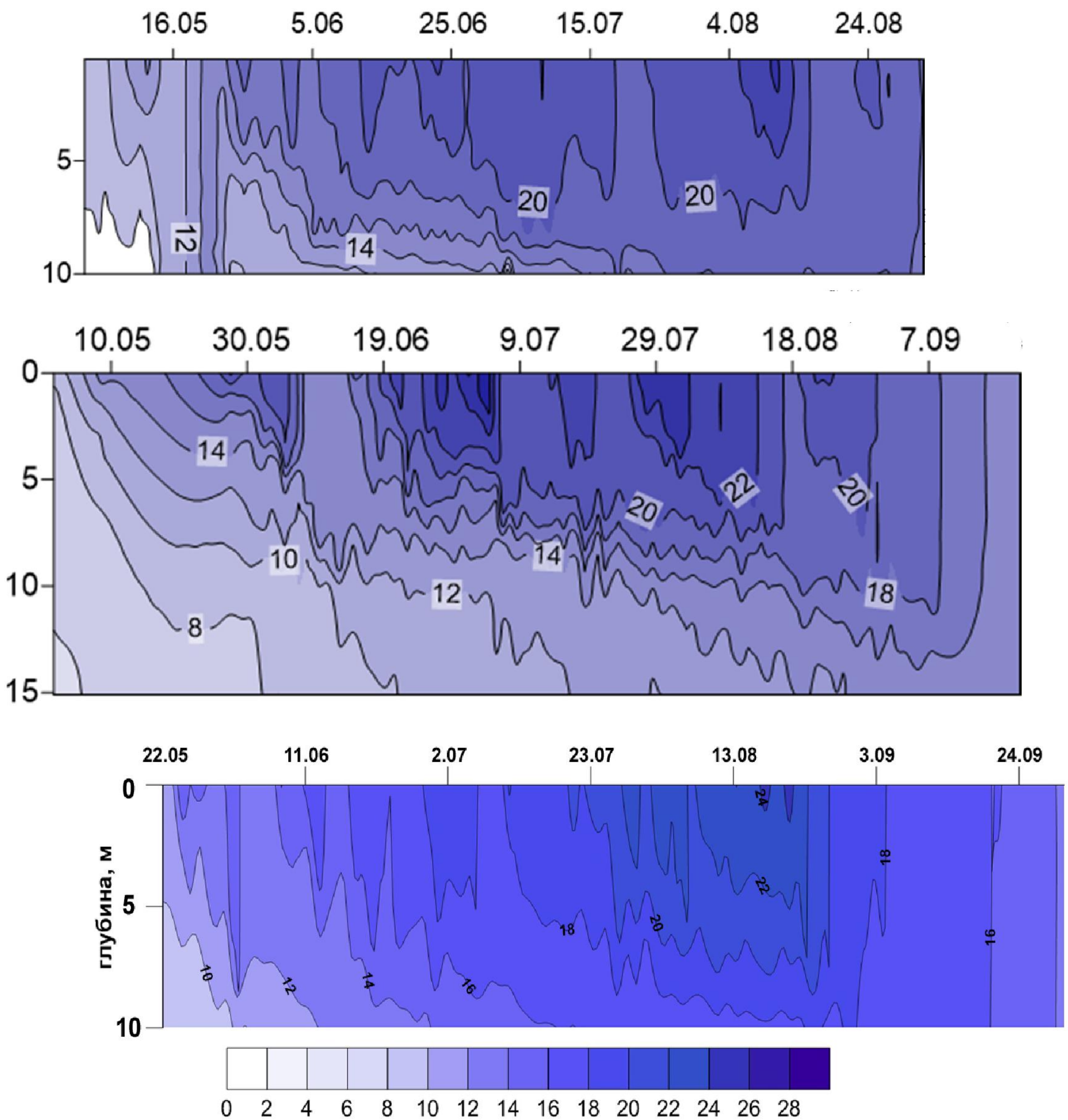


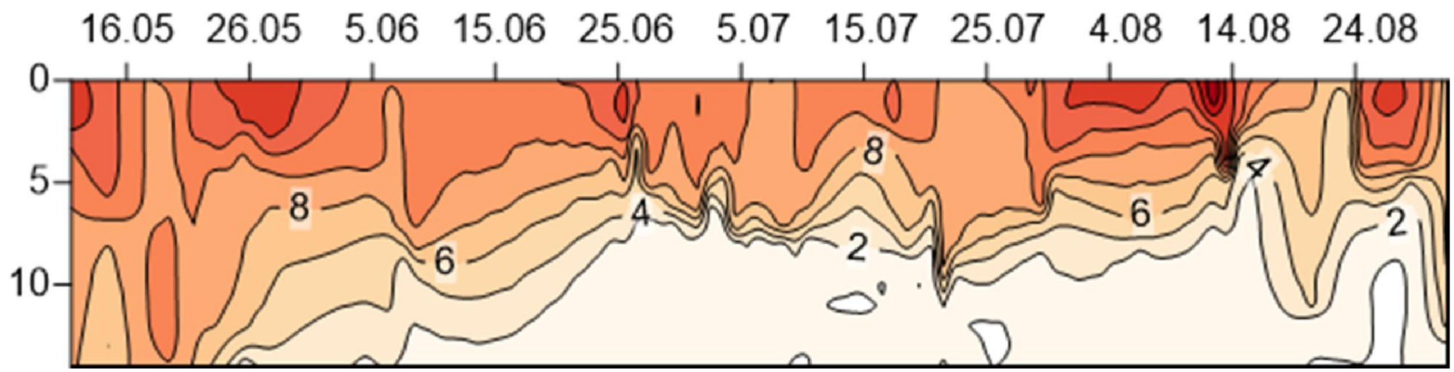
Sampling was fulfilled on stations above flooded river bed (deepest places) and submerged floodplane nearby. These stations have different bottom sediments with different rate of oxygen consumption.

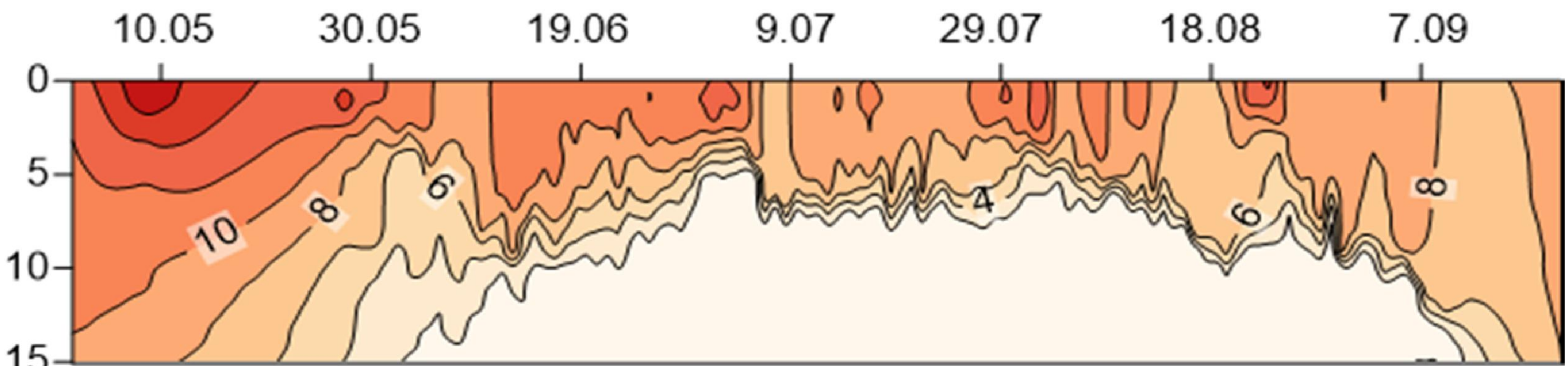


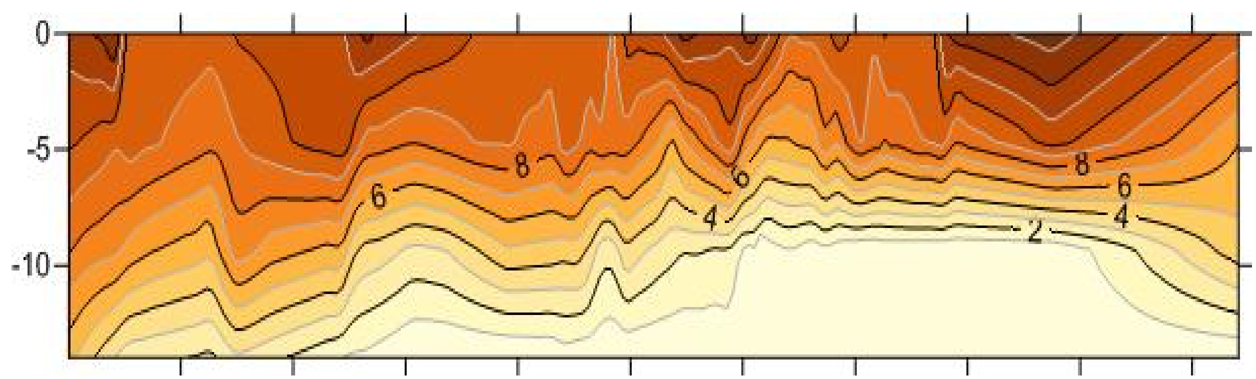
km3
2015
1.01
1.02
4.03
4.04
5.05
5.06
6.07
6.08
6.09
7.10
7.11
8.12
2016
1.01
1.02
3.03
3.04
4.05
4.06
5.07
5.08
5.09
6.10
6.11
7.12
H, м
2016, 2017
2015
2011
2012
2013
2014
2015
2016
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII

Krasnovidovo station

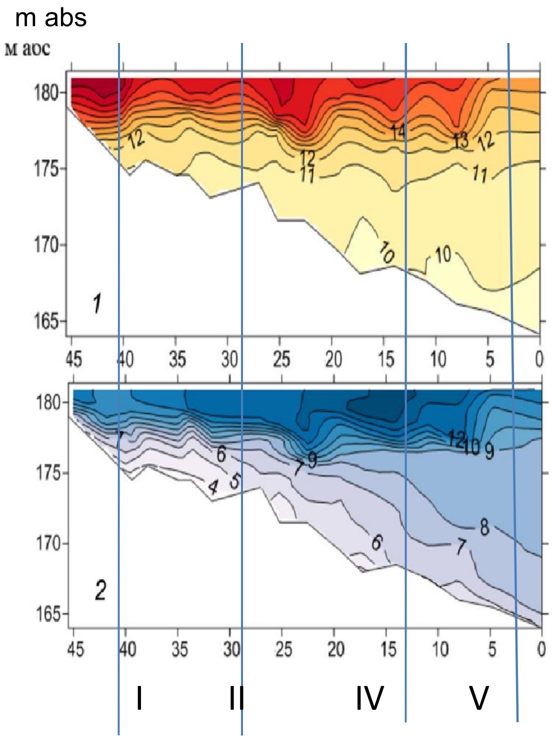



16.05 26.05 5.06 15.06 25.06 5.07 15.07 25.07 4.08 14.08 24.08
0
5
10
8
6
4
2
8
6
4
2


10.05 30.05 19.06 9.07 29.07 18.08 7.09
0
5
10
15
10
8
6
4
6
8

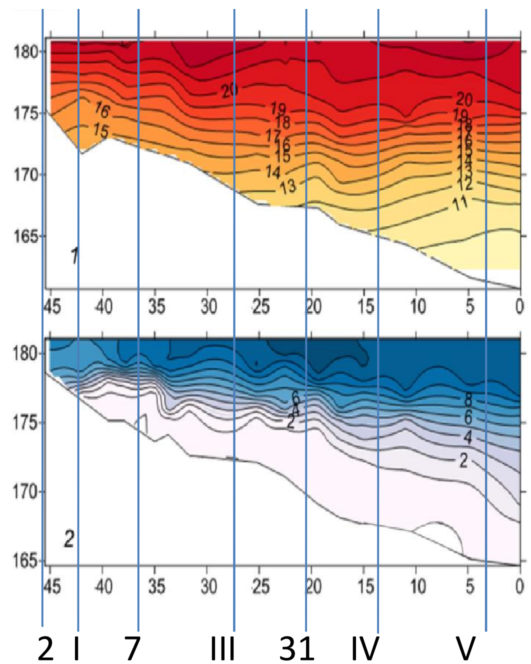

0
-5
-10
8
6
6
4
8
6
4
2

YSI results for 2015 lengthwise survey



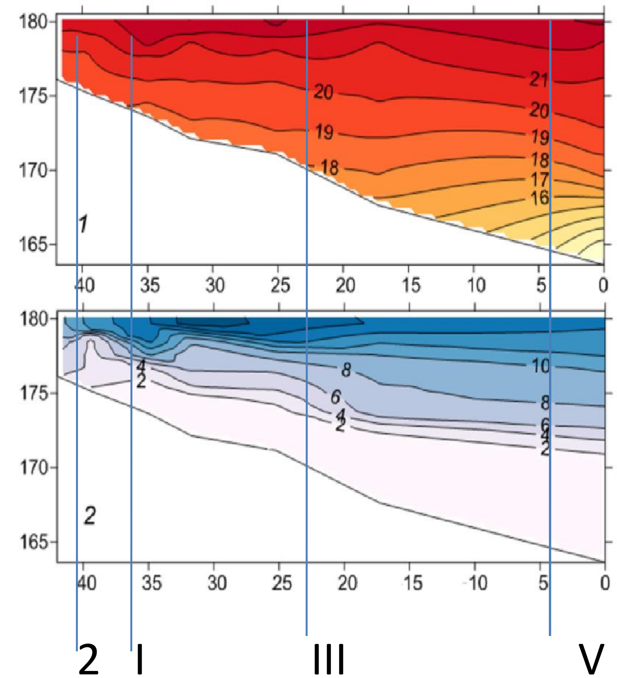
1 – T water, °C; *2* – O_2, mg/l

09 june



1 – T water, °C; *2* – O_2, mg/l

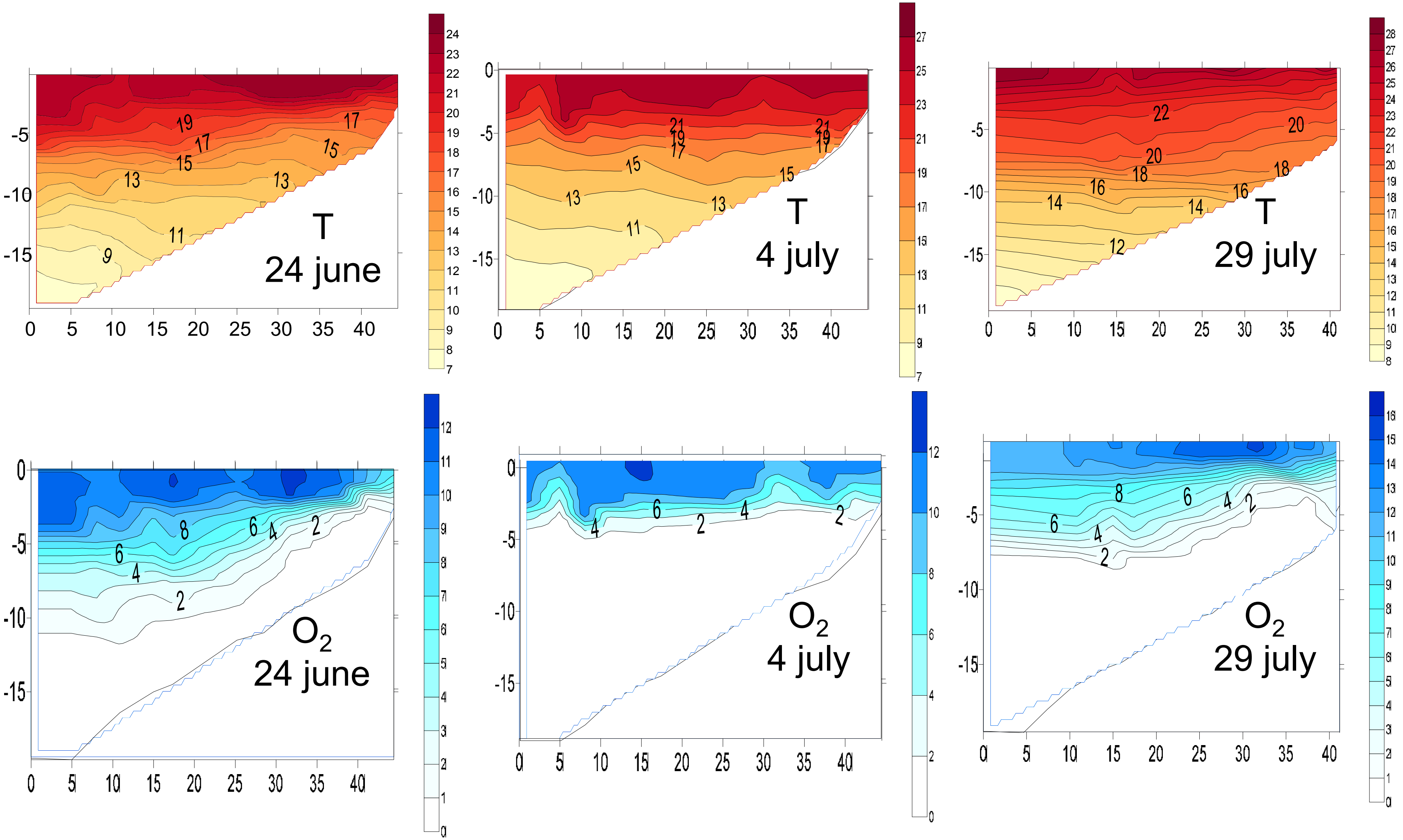
01 july



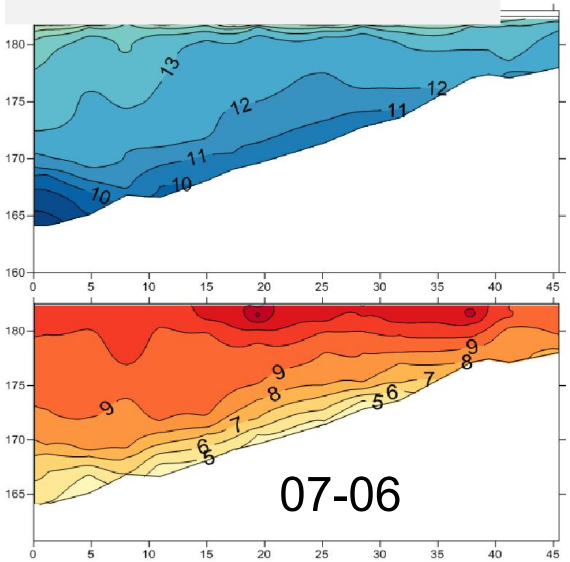
1 – T water, °C; *2* – O_2, mg/l

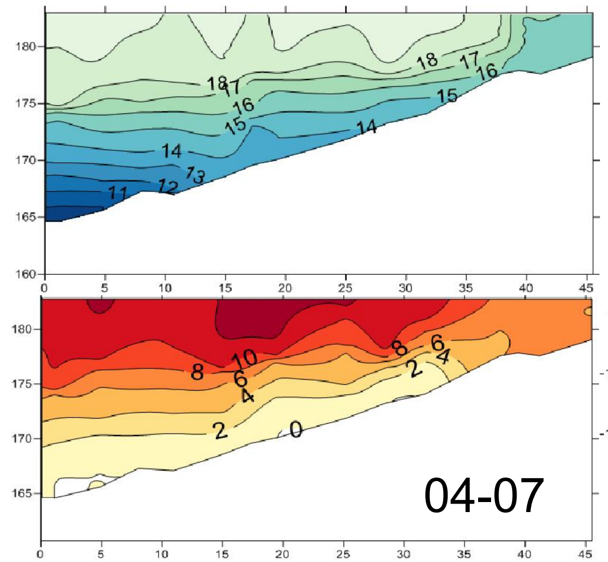
06 august

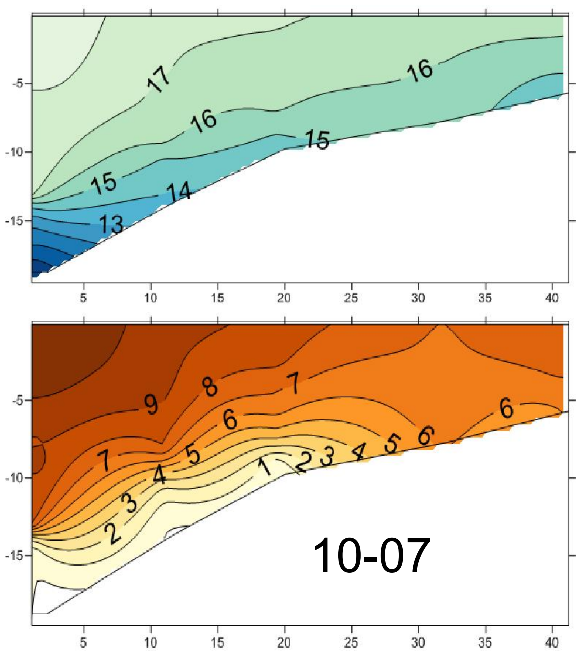
YSI results for 2016

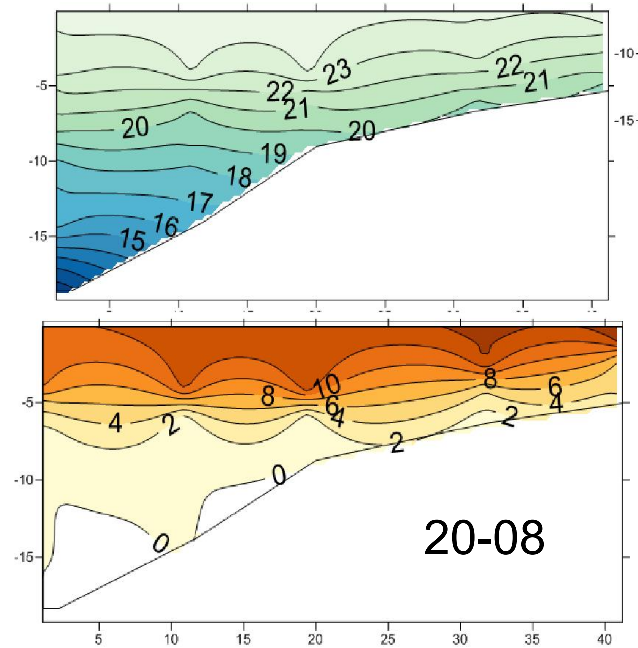


YSI results for 2017

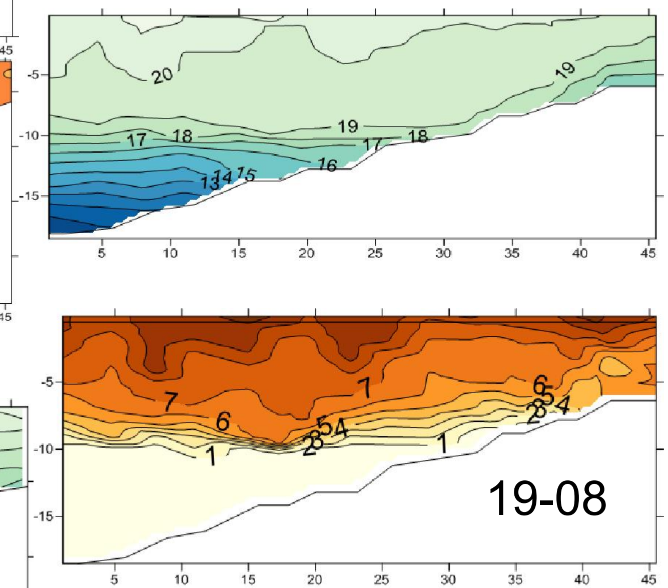


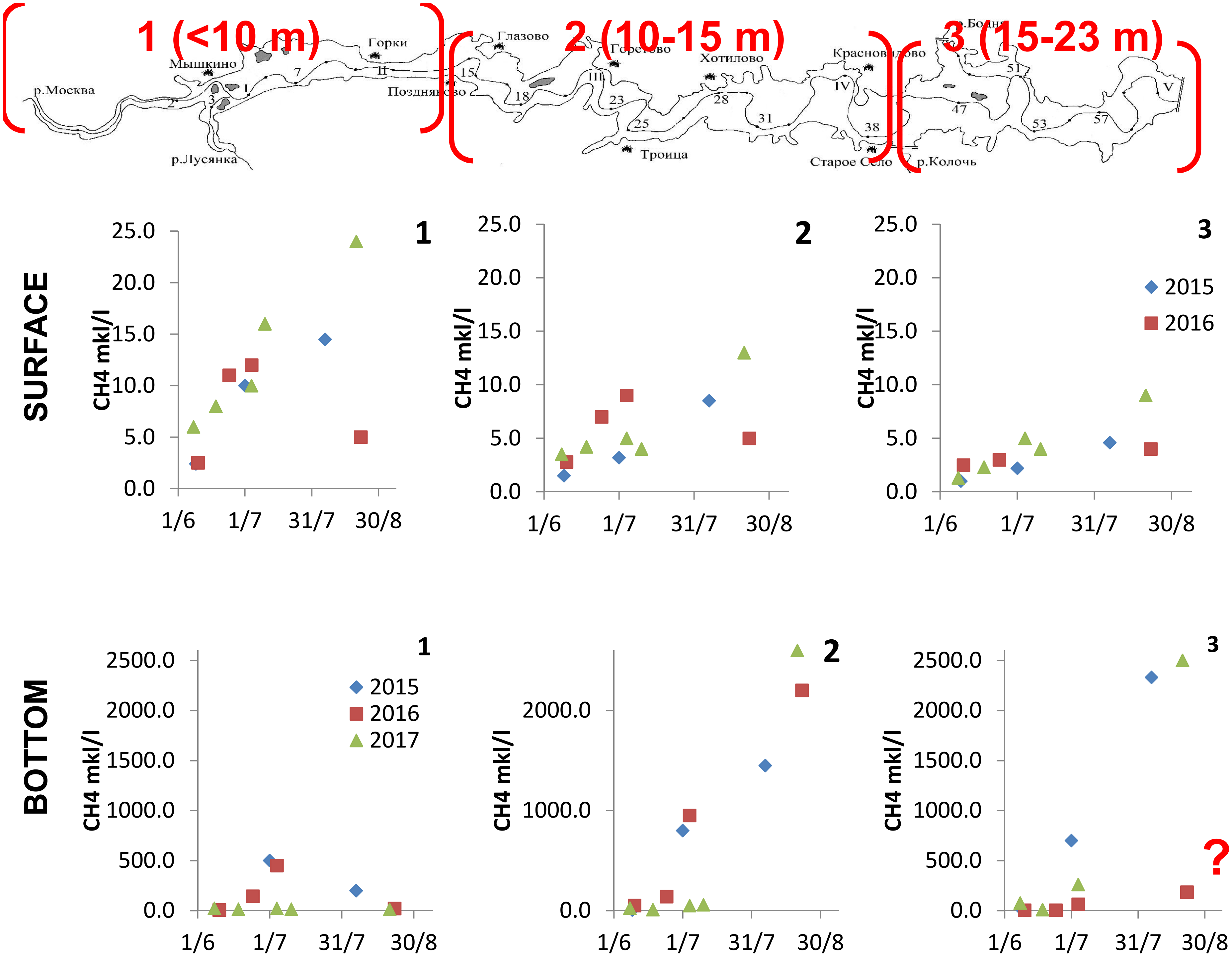




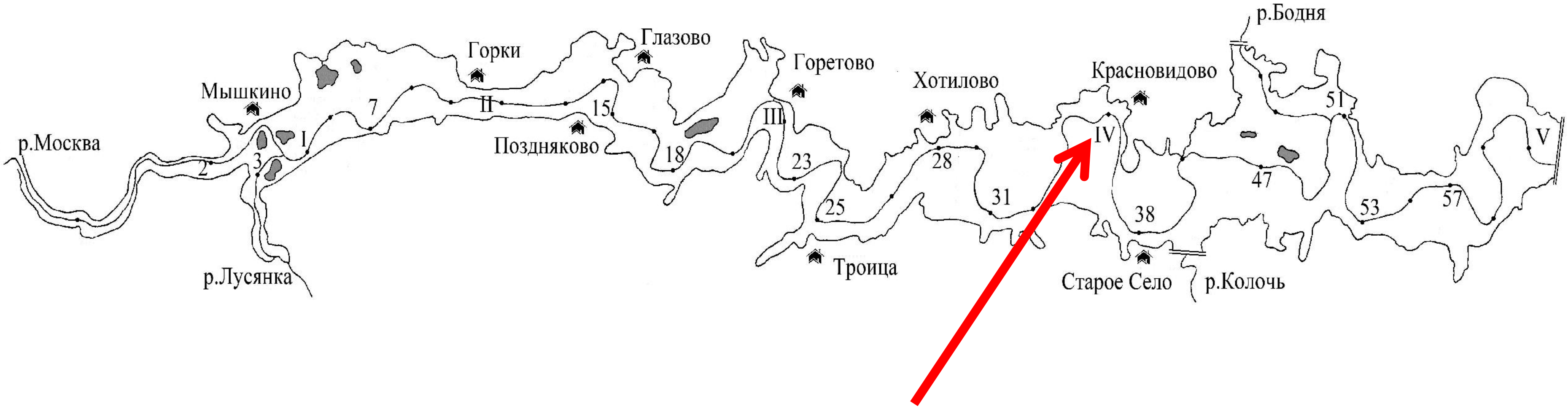


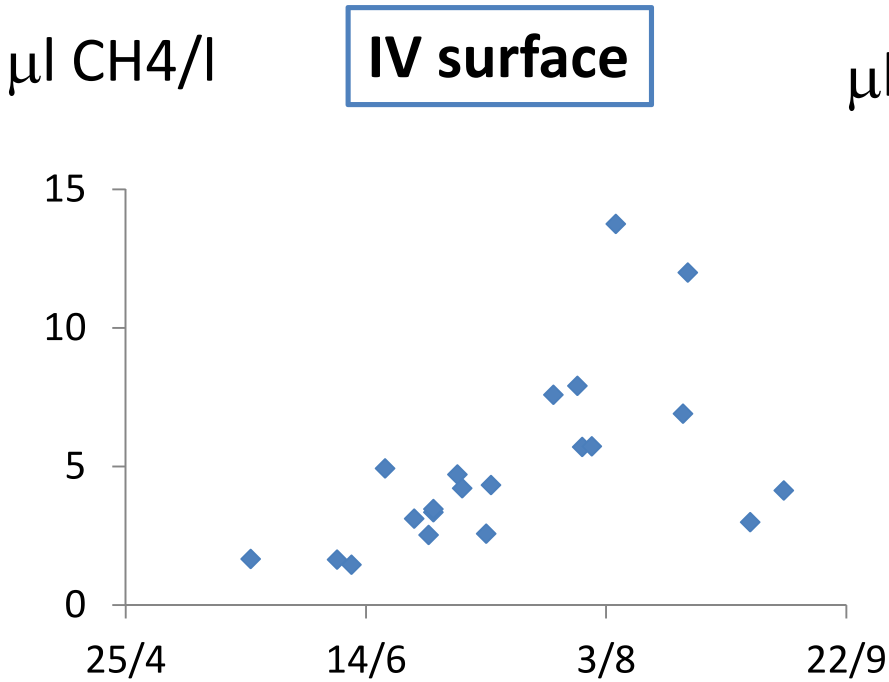
YSI results for 2016

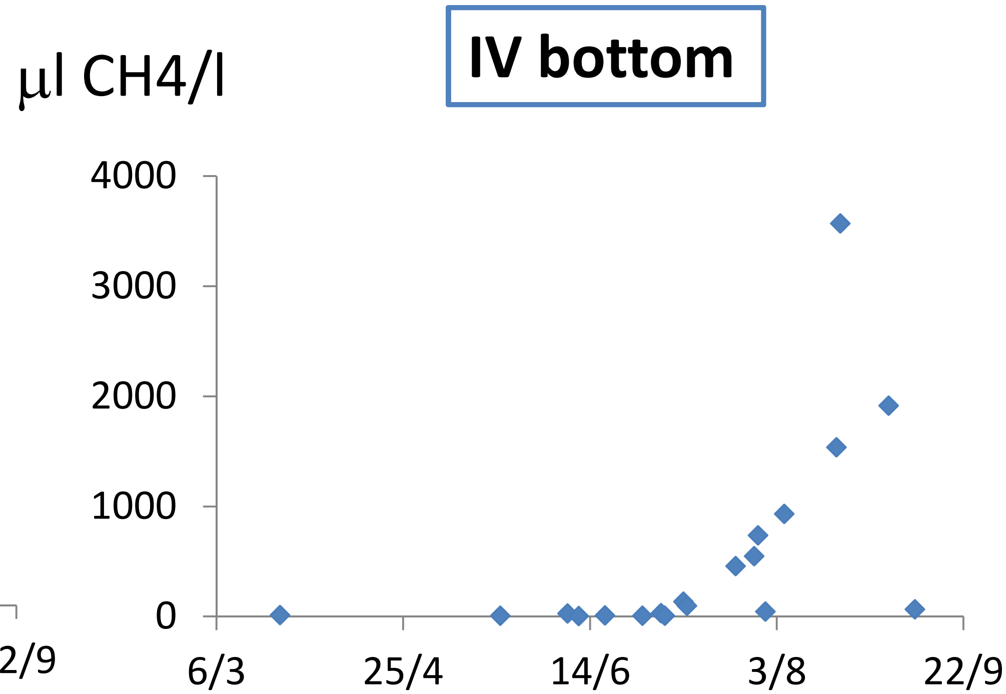




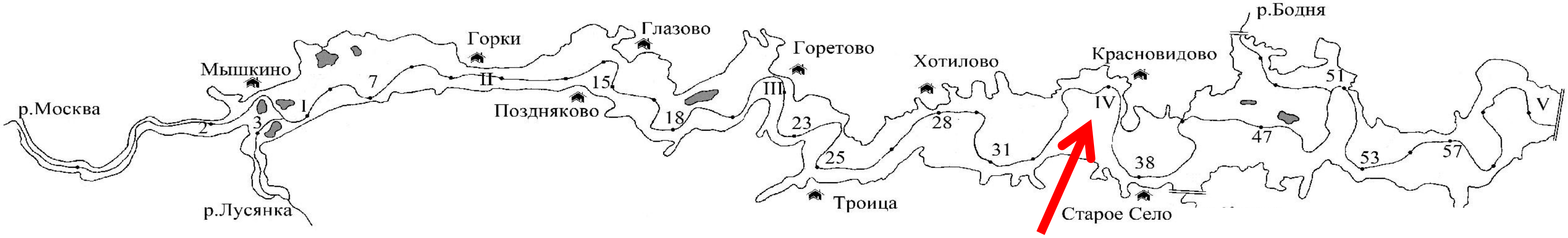
1 (<10 m)
2 (10-15 m)
3 (15-23 m)
р.Москва
Мышкино
Горки
Глазово
Хотилово
Троица
р.Колочь
SURFACE
BOTTOM
CH4 mkl/l
1
2
3
2015
2016
2017
1/6
1/7
31/7
30/8
?

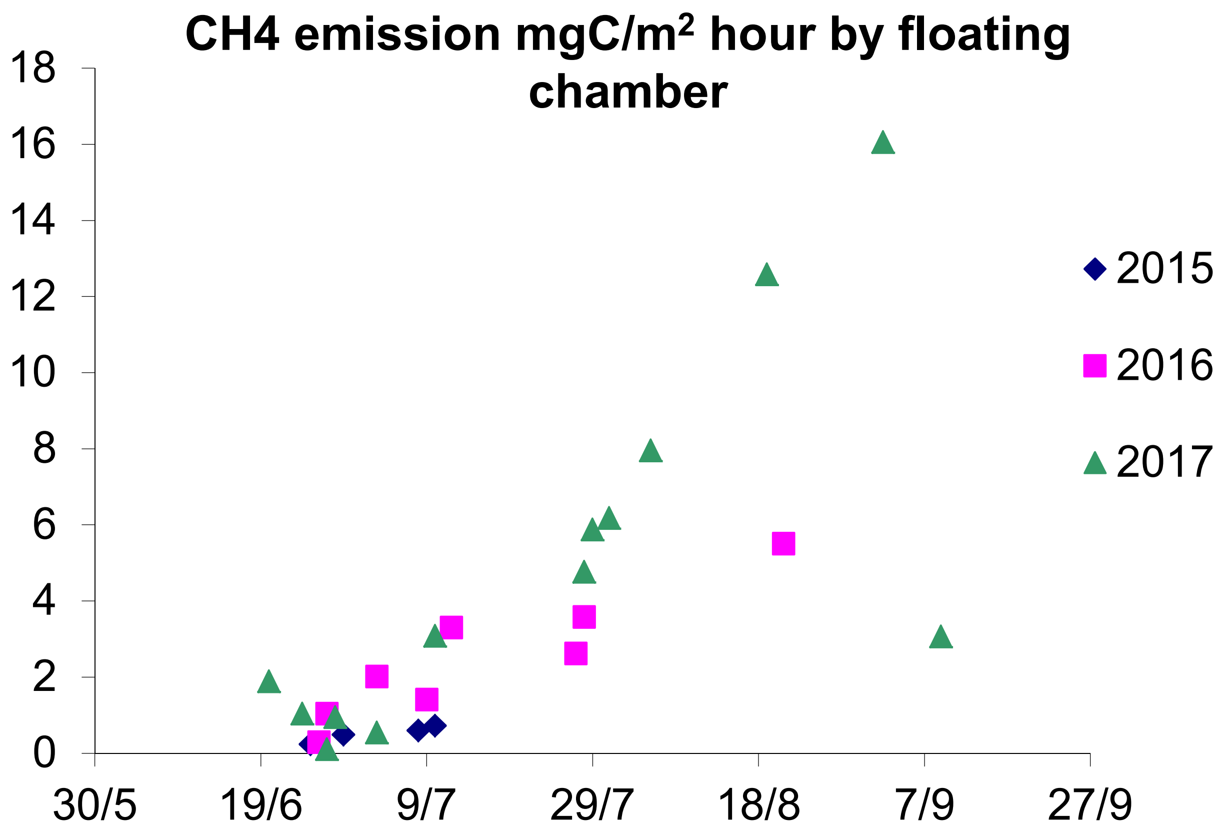

р.Москва
Мышкино
Горки
Глазово
Поздняково
Горетово
Хотилово
Красновидово
р.Бодня
р.Лусянка
Троица
Старое Село
р.Колочь
I
II
III
IV
V
2
3
7
15
18
23
25
28
31
38
47
51
53
57

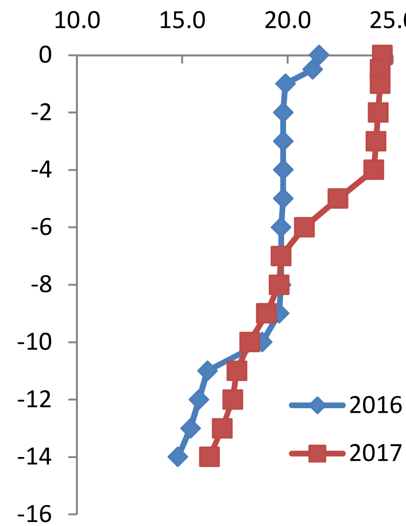

µl CH4/l
IV surface
15
10
5
0
25/4
14/6
3/8
22/9

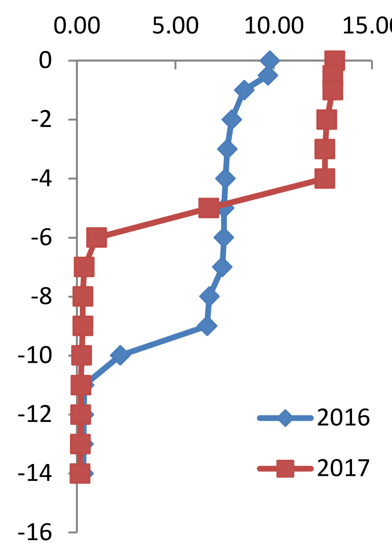

µl CH4/l
IV bottom
4000
3000
2000
1000
0
6/3
25/4
14/6
3/8
22/9

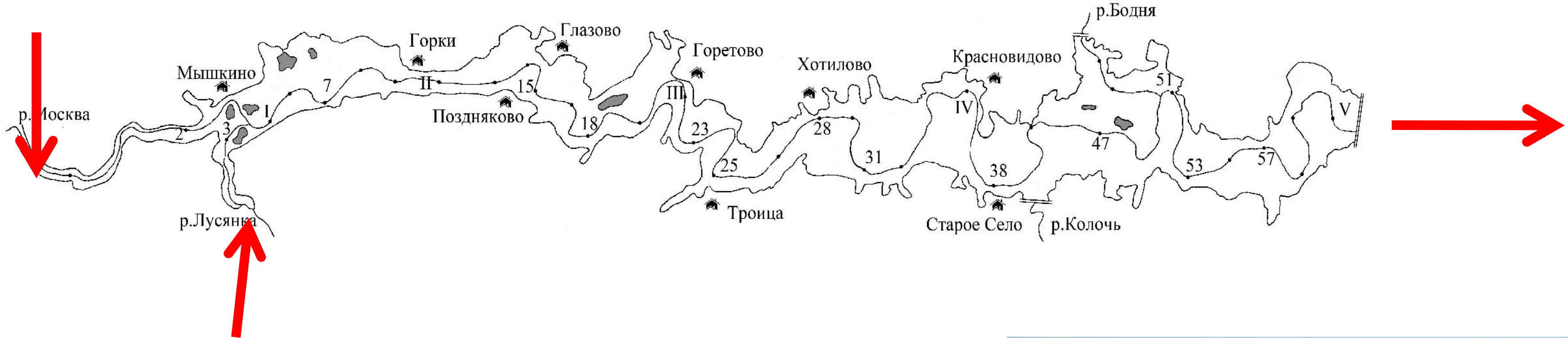
2017

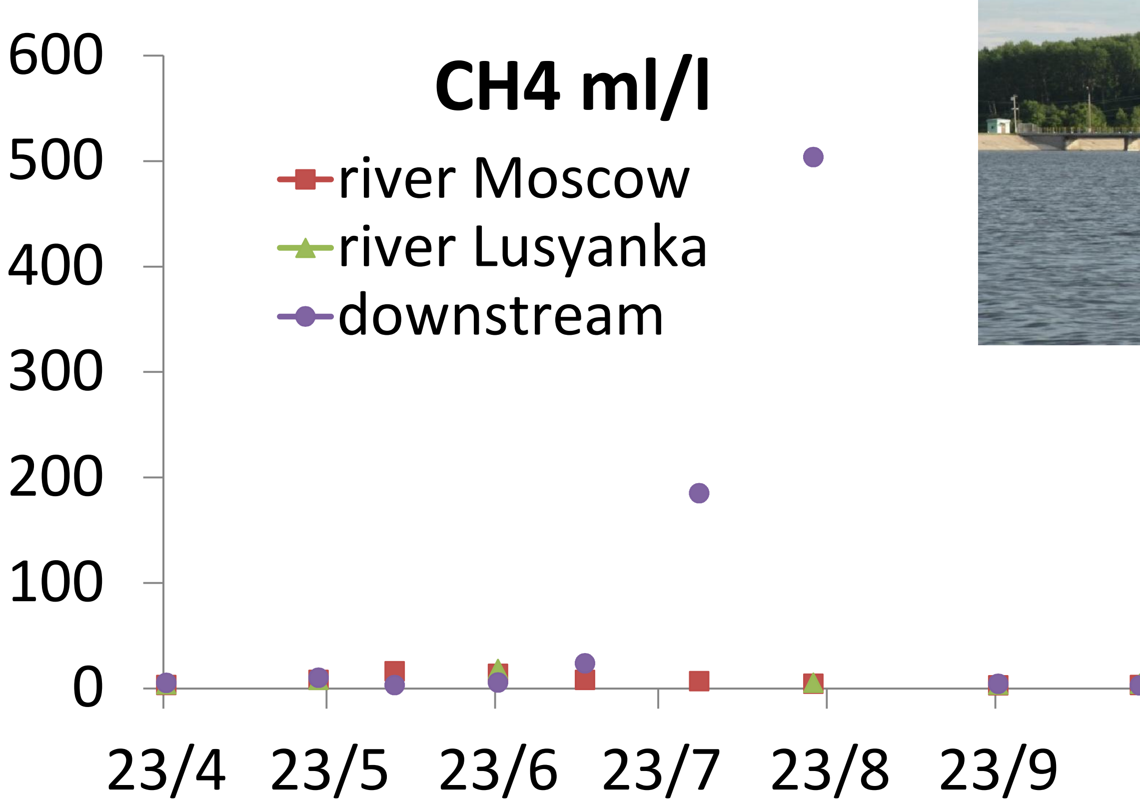

р.Москва
Мышкино
Горки
Глазово
Поздняково
Горетово
Хотилово
Красновидово
р.Бодня
р.Лусянка
Троица
Старое Село
I
II
III
IV
V
2
3
7
15
18
23
25
28
31
38
47
51
53
57


CH4 emission mgC/m2 hour by floating chamber
0
2
4
6
8
10
12
14
16
18
30/5
19/6
9/7
29/7
18/8
7/9
27/9
2015
2016
2017

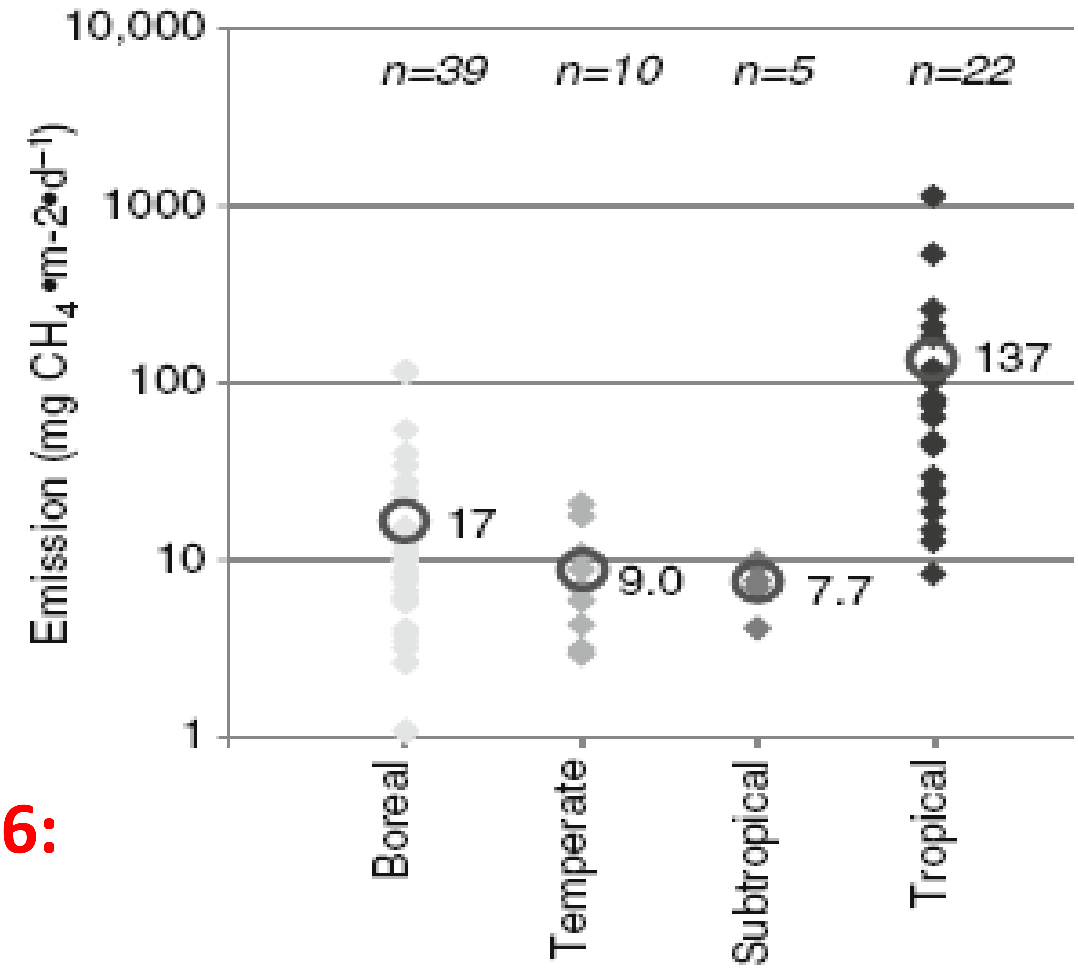

10.0
15.0
20.0
25.0
0
-2
-4
-6
-8
-10
-12
-14
-16
2016
2017


0.00
5.00
10.00
15.00
0
-2
-4
-6
-8
-10
-12
-14
-16
2016
2017


р.Москва
Мышкино
Горки
Глазово
Горетово
Хотилово
Красновидово
р.Бодня
Поздняково
Троица
Старое Село
р.Колочь
р.Лусянка
I
II
III
IV
V


CH4 ml/l
river Moscow
river Lusyanka
downstream
600
500
400
300
200
100
0
23/4
23/5
23/6
23/7
23/8
23/9

Greenhouse Gas Emissions from Reservoirs
Olli Varis et al 2012



96 mg CH4/ m2 day

01.05 – 30.09 2016:

Surface emission 98,89%
Dumping 1,1%
Inflow 0,01%

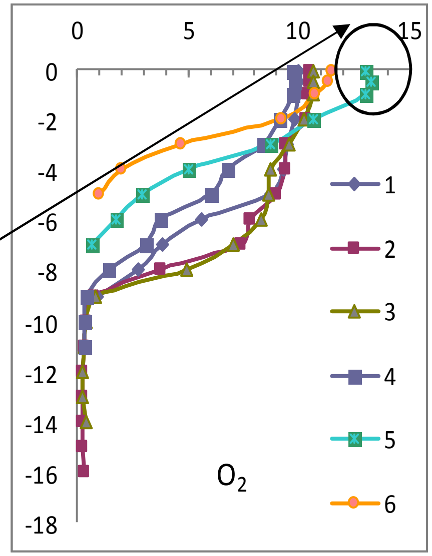
Ozerna reservoir

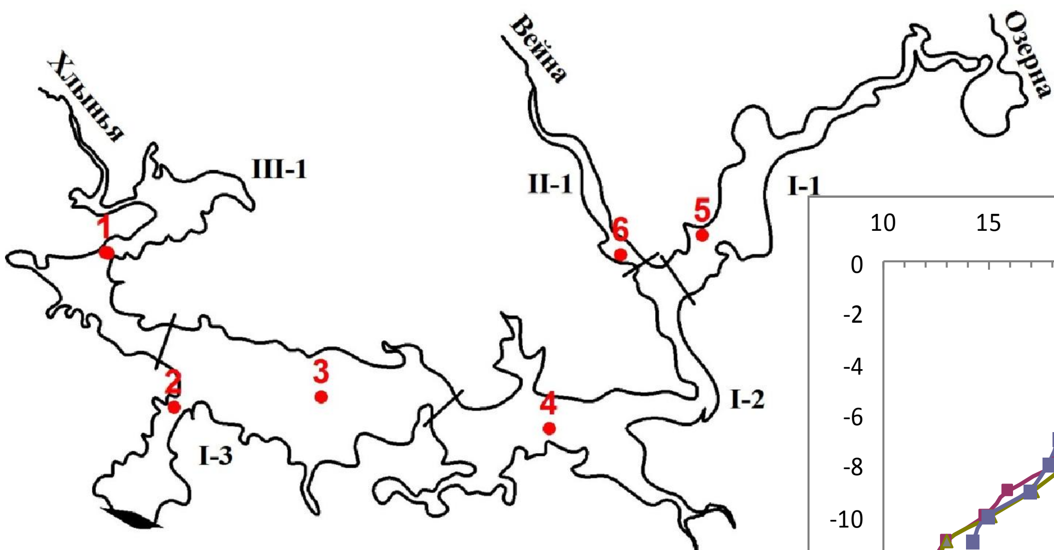
Object and sampling results for 27-07-2015

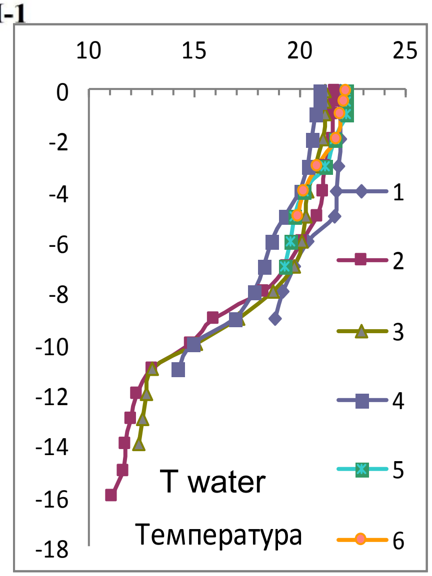
Complicated morphology
On st. 1, 5, 6 (9, 7, 5 m accordingly), CH_4 near bottom is low, reasons:
- Bottom sediments of river mouth gulfs – olive and yellow-brown sandy silt;
- mixing conditions

CH_4 on st. 5 near surface is twice less than on st.6 due to blooming algae producing O_2

The quantity of CH_4 is between results of sampling in Mojaisk reservoir (01.07 and 06.08).







Area (station)	H, m	[CH4], ppm	[CH4], mkl/l
	above the riverbed		
I-1 (5)	0	44,7	5,06
I-1 (5)	7	143,9	**17,36**
I-2 (4)	**air**	2,48	
I-2 (4)	0	34,6	**3,81**
I-2 (4)	11	13905	**1723,74**
I-3 (3)	**air**	2,4	
I-3 (3)	0	30,6	**3,31**
I-3 (3)	14,5	10272	**1273,25**
I-3 (2)	**air**	2,48	
I-3 (2)	0	27,7	**2,95**
I-3 (2)	16,5	8163	**1011,73**
II-1 (6)	**air**	2,55	
II-1 (6)	0	104	**12,42**
II-1 (6)	5	149	**18,00**
III-1 (1)	**air**	2,6	
III-1 (1)	0	61	**7,08**
III-1 (1)	9	95	**11,30**

Similar conditions and processes are the reason for common parameterization of one-type water objects.

Primary synthesis

Long anoxic conditions in the reservoir with slow water exchange contribute to the CH_4 concentration growth in bottom layer in two orders of magnitude:

- **June** – 2-8 μl/l
- July – 90-950 μl/l
- August– 200-2300 μl/l

Seasonal changes of CH_4 in surface layer are connected with reduction of water column stratification stability due to heating of hypolymnion:

1-2,5 μl/l June
2,5-10 μl/l July
4,5-15 μl/l August.

Max CH_4 concentration in the surface layer are typical for shallow upstream

Reasons: rivers inflow (underground waters),
active exchange with bottom layer.

The obtained values exceed CH_4 data in water of reservoirs with quick water exchange (Volga cascade), reported by Dzuban, Fedorov et al.

Conclusions

- Water exchange is an important factor determining thermal, density, primary production and gas regime.
- The morphometry (wind acceleration) makes a significant influence on gas exchange terms between bottom and surface.
- Sampling showed a significant growth of CH_4 in the surface layer during summer period, especially for shallow upstream
- The longitudinal change of the diffusive flux is 10 times more than crosswise
- Mathematical model is the only way to get correct estimations of methane flux from such complicated water objects as valley reservoirs in conditions of not sufficient information